1. Details of Module and its structure

Module Detail	
Subject Name	Chemistry
Course Name	Chemistry 01 (Class XI, Semester 01)
Module Name/Title	Some Basic Concepts of Chemistry: Part I
Module Id	Kech_10101
Pre-requisites	atom, molecule, matter
Objectives	After going through this module you will be able to • explain the role of chemistry in different spheres of life • explain the characteristics of three state of matter • classify different substance as elements, compounds and mixtures • differentiate between physical and chemical properties of matter
Keywords	importance of chemistry, homogeneous mixture, heterogeneous mixture, element, compound, mixture, physical properties, chemical properties

2. Development Team

Role	Name	Affiliation
Course Coordinator	Prof. Rajaram S. Sharma	Central Institute of Educational Technology, NCERT, New Delhi
Principal Investigator (PI)	Prof. Alka Mehrotra Prof. Anjni Koul Dr. Aerum Khan	DESM-NCERT DESM-NCERT CIET-NCERT
Subject Matter Expert (SME)	Dr. Komal S. Khatri	G. B. Pant Institute of Polytechnic, Okhla-II, New Delhi
Content Reviewer	Dr. Alka Mehrotra Dr. Aerum Khan	DESM, NCERT CIET, NCERT
Language Editor	Dr. Alka Mehrotra Dr. Aerum Khan	DESM, NCERT CIET, NCERT

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1. General Introduction: A Nobel Laureate chemist, *Roald Hoffmann* , said that "Chemistry is the science of molecules and their transformations. It is the science not so much of the one hundred elements but of the infinite variety of molecules that may be built from them". Chemistry deals with the composition, structure and properties of matter. These aspects can be best described and understood in terms of basic constituents of matter - atoms and molecules. That is why chemistry is called the science of atoms and molecules (Fig. 1).

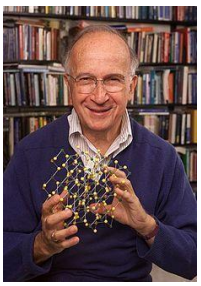

Fig 1: Roald Hoffmann

Roald Hoffmann is an American scientist. A most literary chemist, Hoffman has also published several poems, plays and essays with Robert Burns Woodward he developed rules for elucidating reaction mechanisms. These are known as the Woodward-Hoffmann rules. Their rules are helpful in predicting the products of reaction between two compounds when these are activated by heat compared with those produced under activation by light. For this work Hoffmann was awarded the 1981 Nobel Prize in chemistry, jointly with Japanese chemist Kenichi Fukui who had independently

resolved similar issues. Woodward was not included in the prize, as the prize is given only to living persons.

(Source:https://upload.wikimedia.org/wikipedia/commons/c/c9/Roald_Hoffmann.jpg)

1.1 Importance of Chemistry

Chemistry plays a central role in science and is often intertwined with other branches of science like physics, biology, geology etc. Principles of chemistry are applicable in diverse areas, such as weather patterns, functioning of brain, operation of computers, and production of chemicals in industries. Chemistry contributes in a big way to the economy of the nation. It also plays an important role in daily life. For example, it plays an important role in meeting human needs for food, health care products, and other materials aimed at improving the quality of life. Some of the areas in which chemistry plays an enormous role are discussed in the following paragraphs.

Enhancement of Food Production

Food is our primary requirement. With increase in population and change in standard of life, the quality and quantity of food needs to be taken care of. Chemistry helps in providing chemical fertilizers like urea and different types of pesticides, fungicides and insecticides to protect crops from harmful insects. Thus helps in increasing the overall crop yield.

Improving and Providing Health Care Products

Chemistry provides methods for isolation of life saving drugs from natural sources and helps in the synthesis of such drugs. Some of the examples of such drugs are cisplatin and taxol, which are effective in cancer therapy. The drug AZT (Azidothymidine) which is used for helping AIDS victims is another example of such drugs. Apart from this, new and improved analgesics, anaesthetics and several other effective medicines have been discovered which help in reliving the pain and other ailments. Chemistry plays an important role in increasing the average life span.

Chemistry in the Development and Economy of Nation by Providing Utility Goods

Chemistry contributes to a large extent in the development and growth of a nation. With a better understanding of chemical principles it has now become possible to design and

synthesize new materials having specific magnetic, electric and optical properties. This has lead to the production of superconducting ceramics, conducting polymers, optical fibres etc. It has helped in establishing industries which manufacture utility goods like fertilizers, alkalis, acids, salts, dyes, polymers, drugs, soaps, detergents, metals, alloys and other inorganic and organic chemicals, etc. These Industries contribute in a big way to the economy of nation and generate employment.

Protection of Environment

With the help of chemistry, in recent years success has been achieved in dealing with some of the pressing aspects of environmental degradation. Safer alternatives to environmentally hazardous refrigerants like CFCs (chlorofluorocarbons), responsible for ozone depletion in the stratosphere, have been successfully synthesized. However, problems like management of the Green House gases such as methane, carbon dioxide, etc. understanding of biochemical processes: use of enzymes for large scale production of chemicals and synthesis of new exotic materials are some of the intellectual challenges for the future generation of chemists. A developing country like India needs talented and creative chemists for accepting such challenges. Table-1 shows the pictorial representation of the applications of chemistry in diverse areas.

Table-1: Applications of Chemistry

Applications of Chemistry	Every-day life	Clothing
		Soaps, Detergents
	Agriculture	Fruits and Vegetables
		Food grains
	Health	Drugs Minerals
		Vitamins
	Shelter	Plastics Wood, Metals
		Cement
	Transportation	Diesel

		Biofuels
		Petrol
	Defence	Explosives
		Weapons

To be a good chemist and to accept such challenges one needs to understand the basic concepts of chemistry which begin with the concept of matter. Let us start with the nature of matter

2. Nature of Matter

You are already familiar with the term matter from your earlier classes. Anything that occupies space and possesses mass is called **matter**. For example: clothes, iron, milk, water, air, all living beings etc. are composed of matter. All these occupy space and have mass.

2.1 *States of Matter*

Matter can exist in three physical states: (1) Solid, (2) Liquid and (3) Gas. The constituent particles of matter in these three states can be represented as shown in Fig.1

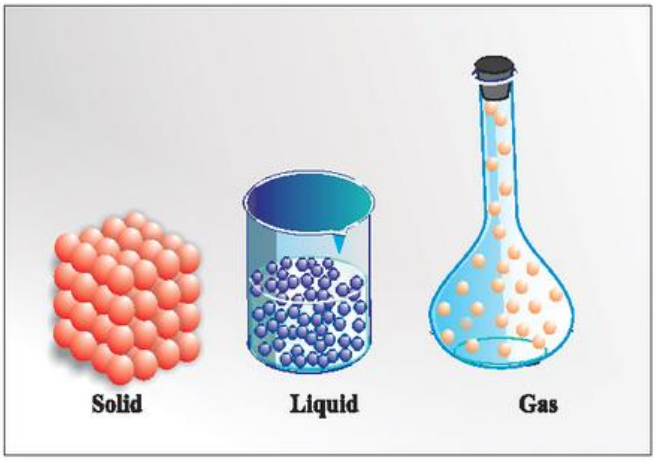

Fig. 1 Three states of Matter: Solid, Liquid and Gas

(Source: Chapter 1, page no. 2, Chemistry Textbook - XI, NCERT)

As it is clear from the picture, particles in solids are held very close to each other in an orderly fashion and there is not much freedom for their movement in the space. In liquids, the particles are close to each other but they can move around in the nearby space and in gases, the particles are far apart as compared to those present in solid or liquid states. Their movement in the space is easy and fast. Because of different arrangement of particles in them, different states of matter exhibit different properties

(1) Solids have **definite volume** and **definite shape.** For example: sugar, gold, wood, etc. These have distinct boundaries and negligible compressibility. Solids have tendency to maintain their shape when external force is applied. Will you consider rubber band and sponge as solids or not? Remember that both rubber band and sponge change shape when external force is applied and regain the shape as soon as the external force is removed unless the force applied is too much to bring about permanent change in the shape .

(2) Liquids possess **definite volume** but they do not have definite shape. They take the shape of the container in which they are placed. For example: water, milk, oil, etc. They are not rigid like solids and thus can be called fluid.

(3) A **Gas** possesses **neither definite volume nor definite shape**. They completely occupy the space in the container in which they are placed. For example: hydrogen, oxygen, air, etc. Particles of the gases move about randomly and with very high speed. Due to high speed and large space between the particles, gases can mix very fast with each other and can be compressed in small space. Also, due to easy and fast movement, particles of gases occupy the whole space in the container and gases have no definite shape and volume. You will learn more about gaseous and liquid state later. These three states of matter are inter-convertible by changing the conditions of temperature and pressure.

$$\text{Solid} \underset{\text{cool}}{\overset{\text{heat}}{\rightleftharpoons}} \text{liquid} \underset{\text{cool}}{\overset{\text{heat}}{\rightleftharpoons}} \text{Gas}$$

On heating a solid usually changes to a liquid and the liquid on further heating changes to gas (or vapour). In the reverse process, a gas on cooling liquefies to the liquid and the liquid on further cooling freezes to the solid. Water is the good example of such change. It can exist in all the three states. On heating ice changes to liquid water which on further heating becomes water vapour which is gaseous form of water. On cooling water vapour change takes place in

the reverse direction. What happens inside the matter during these changes and what is the effect of cooling or heating on the particles of matter is of great interest to a chemist.

2.2 Classification of Matter

At the macroscopic or bulk level, matter can be classified in two classes as:
(i) **mixture and** (ii) **pure** substances. These can be further sub-divided as shown in Fig. 2.

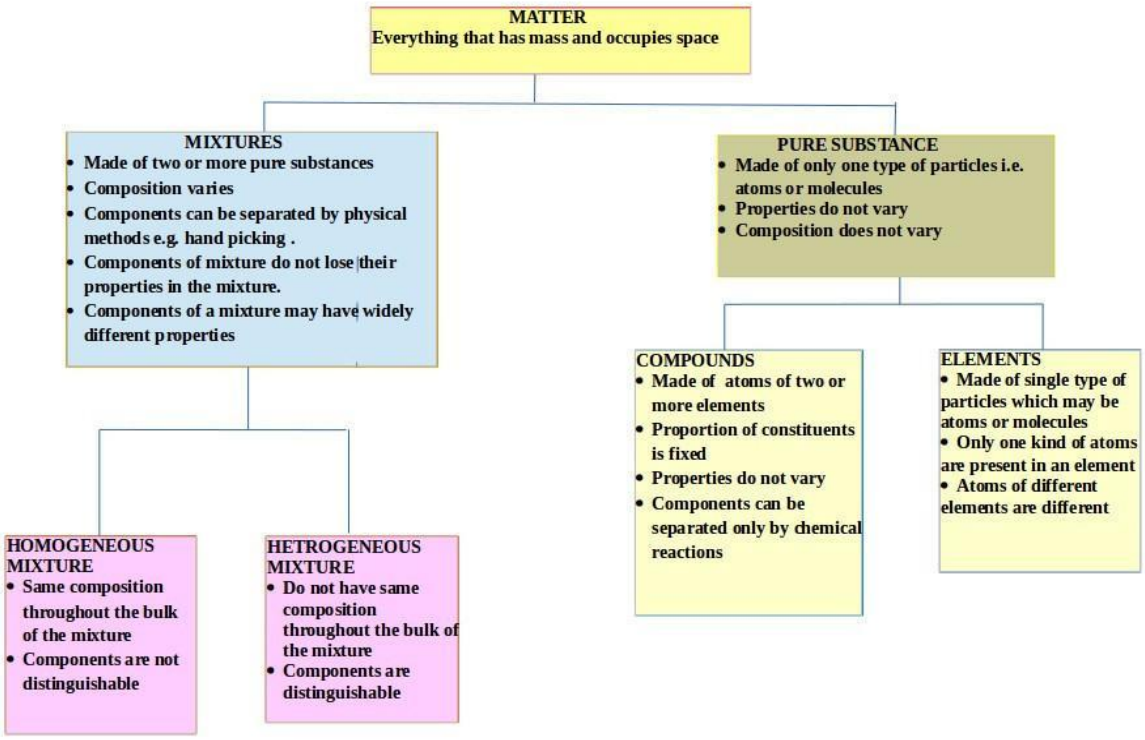

Fig. 2 Classification of matter

(Source: http://employees.oneonta.edu/viningwj/Chem111/Matter.jpg)

Mixture: Many of the substances present around you are mixtures. For example, sugar solution in water, air, tea etc., are all mixtures. A mixture contains two or more pure substances present in it in any ratio, which are called its components. The properties of constituents of a mixture are retained. Also, constituents of a mixture can be separated by simple physical methods. You have learnt about some methods of separation of components of mixtures in your earlier classes.

Depending upon the distribution of particles of components of a mixture in the bulk, a mixture is called homogeneous or heterogeneous. Components of a **homogeneous mixture** mix uniformly with each other and its composition is same throughout the bulk of the

mixture. For example sugar solution tastes the same throughout. This shows that particles of sugar are evenly distributed in the solution. Air is also an example of homogeneous mixture. Particles of homogeneous mixture are not visible with naked eye or even with microscope. These mixtures have a single state. For example, air is mixture of different gases and is in gaseous state. Sugar solution is made by mixing sugar (solid) and water (liquid) but the mixture, i.e., sugar solution is liquid. Alloy like brass is a mixture of different metals (solids) and is a solid.

In contrast to this, composition of heterogeneous **mixtures** is not uniform throughout. Sometimes the components of these mixtures can be observed. For example, a mixture of salt and sugar and a mixture of grains and pulses along with some dirt (often stone pieces), are heterogeneous mixtures. Components may exist in different states. The components of a mixture can be mixed in any proportions. These components retain their characteristic properties even after mixing. It is worthwhile to mention here that the components of a mixture can be separated by using physical methods such as simple hand picking, filtration, crystallisation, distillation etc. For example, components of a mixture of iron nails, sulphur and common salt retain their distinct characteristic properties even after mixing. Iron nails can be separated from the mixture by using a simple magnet. While other two components i.e. common salt and sulphur can be separated by using some solvent in which only one of the components dissolves. For example common salt is soluble in water while sulphur is insoluble in water so components can be easily separated from the mixture by using water as solvent. Alternatively carbon disulphide can be used to separate the components because sulphur is soluble in carbon disulfide while common salt is insoluble in it. Fig. 3 shows the scheme for the separation of components of a heterogeneous mixture of iron filings and sulphur both of which are solids.

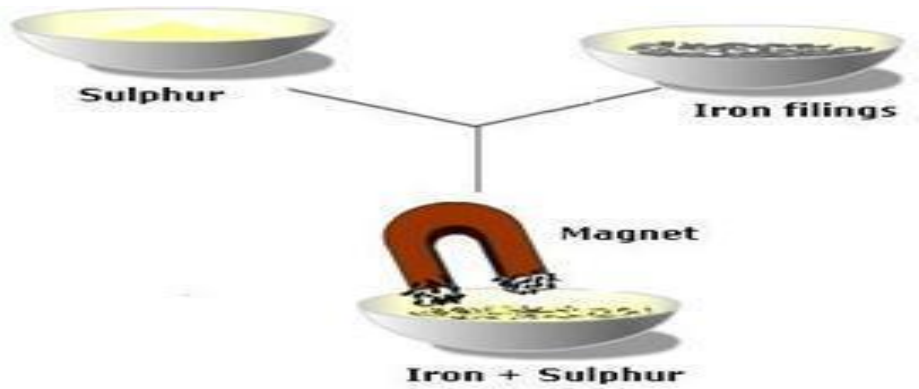

Fig. 3: Separation of components of a heterogeneous mixture of iron filings and sulphur.

Source: https://c2.staticflickr.com/8/7076/13579817603_513813421d_b.jpg)

Pure substances are composed of only one type of particles. These particles may be atoms or molecules. Also, the constituents of pure substances cannot be separated by simple physical methods. Copper, silver, gold, water, glucose are some examples of pure substances. Glucose contains carbon, hydrogen and oxygen in a fixed ratio and thus, like all other pure substances has a fixed composition. Pure substances can be further classified into elements and compounds. Particles of an *element* consist of only one type of atoms. These particles may exist as atoms or molecules. For example: Carbon, sodium, copper, silver, hydrogen, oxygen, etc. are elements. Their all atoms are of one type. Fig. 4 shows that diamond consists of only one type of atoms i.e. carbon.

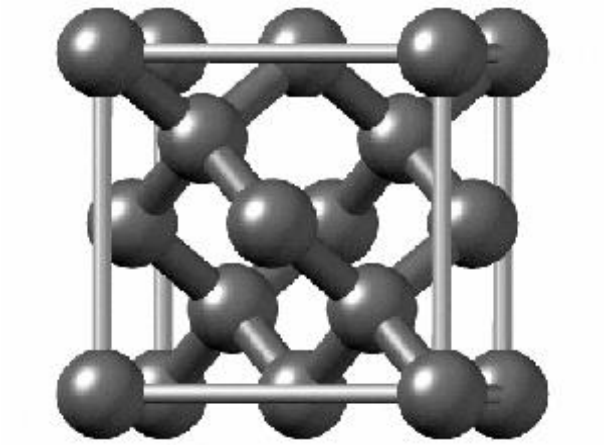

Fig.4 Molecular view of a Carbon element

(Source:https://upload.wikimedia.org/wikipedia/commons/8/89/Diamond_cubic_animation.gif)

However, atoms of different elements are different in nature. Some elements such as sodium or copper contain atoms as their constituent particles whereas in some others constituent particles are molecules which are formed by two or more same type of atoms. For example, hydrogen, nitrogen and oxygen gases consist of molecules in which two atoms combine to give their respective molecules. This is illustrated in Fig. 5. Till date 118 elements are known.

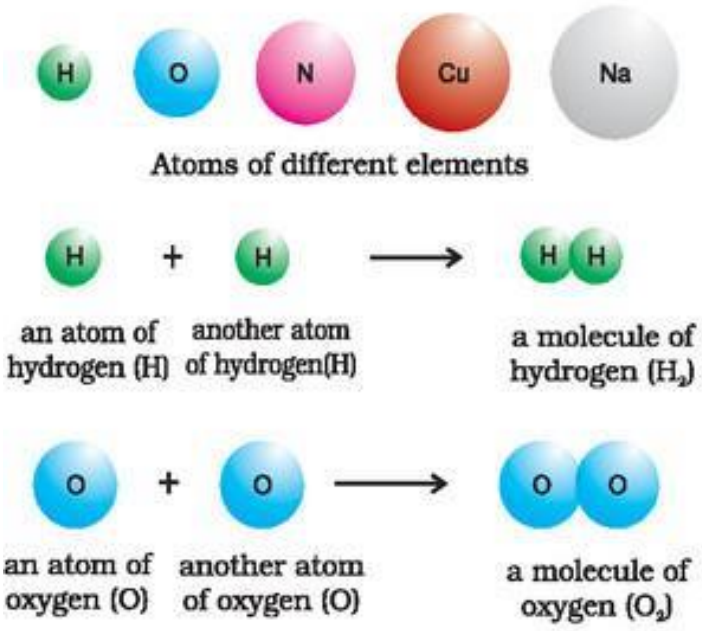

Fig.5 A representation of atoms and molecules

When two or more atoms of different elements combine together in a definite ratio, molecule of a **compound** is obtained. The atoms of constituent elements of compounds cannot be separated by using simple physical methods, rather suitable chemical reactions are employed for their separation. The properties of a compound are entirely different from the characteristic properties of its constituent elements. The examples of some compounds are water, ammonia, carbon dioxide, sugar, etc. The molecules of water and carbon dioxide are represented in Fig 6.

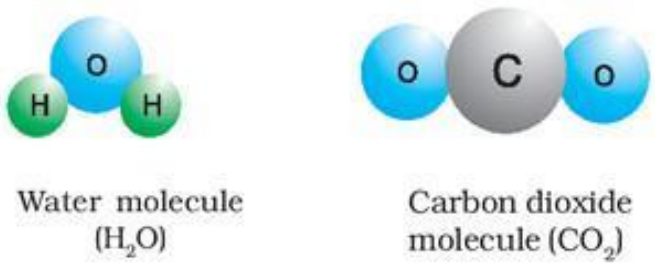

Fig. 6 A depiction of molecules of water and carbon dioxide
(Source: Chapter1, page no. 4, Class XI, NCERT)

Figure 6 shows that a water molecule comprises of two hydrogen atoms and one oxygen atom. Similarly, a molecule of carbon dioxide contains two oxygen atoms combined with one

carbon atom. Thus, atoms of different elements are present in a fixed and definite ratio and this ratio is characteristic of a particular compound. Also, the properties of a compound are different from those of its constituent elements. For example, hydrogen and oxygen are gases whereas the compound formed by their combination i.e., water is a liquid. It is interesting to note that hydrogen burns with a pop sound and oxygen is a supporter of combustion, but water is used as a fire extinguisher. Hydrogen and oxygen cannot be separated from water by simple physical methods. However, water can be decomposed into its constituents (i.e. hydrogen and oxygen) by the process of electrolysis. Similarly, carbon and oxygen are present in the definite ratio of 1:2 in the molecule of carbon dioxide. Some other common examples of compounds are sulphur dioxide, sulphuric acid, common salt, baking soda, nitric acid etc.

2.3 Properties of Matter

Every substance has unique characteristic properties, for example colour, odour, melting point, boiling point, composition, etc. These properties can be classified as physical properties and chemical properties. Colour, odour, melting point, boiling point, density, volume, etc., are examples of physical properties and combustibility, composition, reaction towards acids or bases etc. are examples of chemical properties. Chemists describe, interpret and predict the behaviour of substances on the basis of knowledge of their chemical and physical properties which are determined by careful experimentation.

The measurement or observation of *chemical properties* requires a chemical change to occur while measurement of physical properties does not require any chemical reaction to occur. The examples of chemical properties are characteristic reactions of different substances; these include acidity or basicity, combustibility etc.

3. Summary

This module explained the importance of chemistry and its domain in every sphere of life. Chemists study the properties and structure of substances and the changes undergone by them. All substances contain matter which can exist in three states – solid, liquid or gas. The constituent particles are held in different ways in these states of matter and they exhibit their characteristic properties. Matter can also be classified into elements, compounds or mixtures. An element contains particles of only one type which may be atoms or molecules. The

compounds are formed when atoms of two or more elements combine in a fixed ratio to each other. Mixtures occur widely and many of the substances present around us are mixtures.

In the last section of this module, the different types of properties of matter are discussed. Properties of matter classified into physical and chemical properties depending upon the change in their identity or composition during measurement. Also, based on their numerical measurement, classification of properties of matter is done into qualitative and quantitative properties.